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16. ABSTRACT The paper describes an extensive program to define the effects of operating and maintenance practices on the transfer efficiency of spray painting. Three spray painting systems were used: air-atomized conventional, air-atomized electrostatic, and airless conventional. More than 30 operating variables were initially identified and evaluated. Eight were found to be most important and received intensive testing: restricted air lines, booth air rate, gun cleanliness, restricted paint lines, fan or shaping air, gun tip erosion, electrode position, and tip voltage. Copyright 1987

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Optimizing Transfer Efficiency in Spray Painting

By Charles H. Darvin

Between 1984 and 1986, the U.S. EPA's Air & Energy Engineering Research Laboratory and its contractor, Centec Inc. of Reston, VA, conducted an extensive program to define the effects of operating and maintenance practices on the transfer efficiency of spray painting.

Three spray painting systems were used—air-atomized conventional, air-atomized electrostatic, and airless conventional.

Over 30 operating variables were initially identified and evaluated. Eight of these were found to be most important and received intensive testing: restricted air lines; booth air rate; gun cleanliness; restricted paint lines; fan or shaping air; gun tip erosion; electrode position; and tip voltage. The complete results, together with mathematical regression equations, can be found in an EPA publication entitled "Transfer Efficiency of Improperly Maintained or Operated Spray Painting Equipment Sensitivity Studies" (EPA-600/2-85-107). The report is available from the National Technical Information Service (NTIS PB-86-108271), 5285 Port Royal Rd., Springfield, VA 22161.

Cost-Saving Tool

Judicious use of paint is essential for profitable installations. And, now, managers of paint departments can use a mathematical tool to evaluate the impact of atomizing air pressure and other variables on paint consumption.

—Dr. George E.F. Brewer, AESF technical specialist, Organic Finishing & Chemical Pretreatment

Experimental Setup

The experimental design selected for each equipment type consisted of a fractional factorial design augmented by a star design and a set of replicates. The experimental design resulted in an nth-degree matrix from which regression models were developed.

The painting targets used during the program consisted of a bank of flat panels and vertical cylinders wrapped with weighed aluminum foil. After each test run, the foils were dried, removed from the target, and reweighed. The target configurations are shown in Fig. 1 and the transfer efficiency is defined as follows:

$$TE = \frac{\text{wt of paint solids deposited}}{\text{wt of paint solids sprayed}} \times 100\%$$

Test Results

High points of the test results are reported here:

- *Air-Atomized Conventional:* The variables examined for this system were: restricted atomizing air lines; booth air rate (linear velocity); gun cleanliness; restricted paint lines; and fan air (horn or shaping air). Obviously, the shape of the target, or workpiece, influences transfer efficiency, yet there are basic consistencies.

Some of the results are intuitively expected, but their magnitude can now be mathematically defined in the form of regression equations. For instance, transfer efficiency decreases with the degree of restriction in the atomizing air lines and as the booth air rate is increased. The influence of gun cleanliness was not a key factor. Increases in paint line restrictions up to a certain level increase transfer efficiency, which decreases sharply as the fan air control is changed toward the shut position. The latter variable outweighs all of the other evaluated factors combined.

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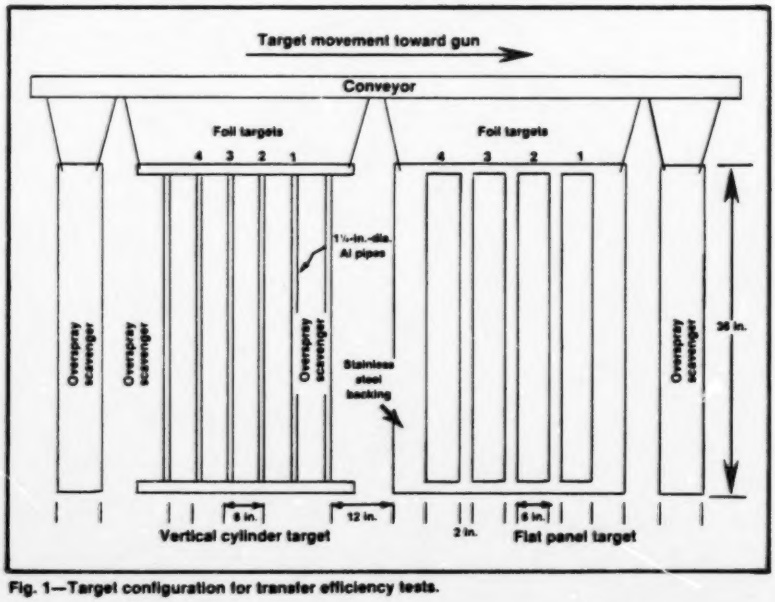

Fig. 1—Target configuration for transfer efficiency tests.

Charles H. Darvin
Physical Scientist
U.S. EPA
Air & Energy Engineering Research Lab.
Research Triangle Park, NC 27711

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restricted paint lines; fan air; tip voltage; and electrode position.

As air pressure increases, the transfer efficiency decreases. This effect, however, can be moderated by reducing the booth air rate and/or the fan air. Restricted paint lines increase transfer efficiency, indicating that an increase in paint pressure has the same effect. Typically, gun cleanliness has less impact than the other operating and maintenance procedures.

• *Airless Conventional:* The test variables were booth air rate, tip erosion, and restricted paint lines.

The only significant variable identified during the experiments was tip erosion, which was simulated using progressively larger tip hole diameters. As tip erosion progresses, the apparent transfer efficiency decreases.

General Conclusions

Most expectations of the impact of operating and maintenance procedures on transfer efficiency were confirmed. More important, the magnitude of the influence of the variables studied was mathematically defined and a tool for predicting apparent transfer efficiency was designed.

The results of this program indicate the relative importance of each variable for a certain target configuration. Laboratory test runs can be used to determine combinations of variables that result in optimum transfer efficiency and high-quality painted finishes for workpieces with different configurations. □

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• *Air-Atomized Electrostatic:* Seven variables were selected: restricted atomizing air lines; booth air rate (linear velocity); gun cleanliness;

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